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USING MIXOGRAPH PARAMETERS AND SOME QUALITY PROPERTIES IN SELECTION OF DURUM WHEAT GENOTYPES

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This research was carried out in order to determine some chemical, physical and rheological (mixograph) traits of 4 standard durum wheat varieties and 11 durum wheat lines in 2015-2016 under irrigated conditions in Gözlü and Central location of Konya according to randomized block design with three replications. Means of quality parameters varied for thousand kernel weight (30.26-38.45 g), protein ratio (12.94-14.77%), SDS sedimentation (13.75-29.75 ml), color (b value) (20.45-23.35), mixograph development time (1.55-3.79 min), peak height (46.47-81.38%), softening (slope) (6.46-28.85 min/%), peak width (2.19-15.13%), peak area (54-165 Nm) and total area (energy) (236-407 Nm). Significant differences were found between wheat varieties in terms of examined features. Durum wheat lines having weak, strong and very strong gluten were identified in this research.

Keywords: Wheat breeding, landraces, genetic structure, semolina, dough traits, gluten index, mixograph parameters.

INTRODUCTION

Turkey is one of the centers of the durum wheat genes in terms of ecology and has very favorable properties for growing up of high quality durum wheat, and some places farmers still grow landraces (Kan *et al.,* 2015). IGC (International Grain Council) figures demonstrates that global durum wheat production has achieved 40.7 million tons in the 2016-17 growing season. Top producers are 28 European Union countries with 9.5 million tons. Turkey ranks 3rd in the world with 3.2 million tonnes of production after Canada (6.5 million tonnes) and Italy (3.9 million tonnes) (IGC). Durum wheat carries a great importance as the raw material of numerous foods such as macaroni and semolina in the alimentation of world population (Yagdi and Sozen, 2009). Although durum wheat accounts for only 5 to 8% of the world wheat production, it is an economically important raw material due to its unique characteristics and use in the production of pasta products (Anonymous, 2016). Bread wheat flour is used in making bread, cookies and some pastries, while semolina and flour obtained from durum wheat is used in making pasta, couscous, bulgur and freekeh (Branković *et al*., 2018). The regional distribution of durum wheat production in Turkey reveals that the highest production in Southeastern Anatolia Region with 1.4 million tons followed by Central Anatolia (989 thousand tons), Aegean (481 thousand tons) and Mediterranean Territories (320 thousand tons) (Anonymous, 2014a). Among the products exported by our country, macaroni and bulgur have an important place. The export quantity of macaroni was 735 thousand tons and bulgur was 179 thousand tons in the year 2014 (Anonymous, 2016). In order to be effective on the outside market, we need to increase our competitive power by producing good quality. By means of durum wheat breeding studies, it has been tried to improve varieties with better quality, high yielding, resistant to diseases and adapted to the conditions of the environment where they are grown. Although many of the quality traits are related to the genetic structure of the variety, some of them (such as protein content) are affected by environmental conditions. During the last half of the past century one of the main aims of breeding programs in Mediterranean environments was to obtain high quality standard durum wheat cultivars (Subira *et al*., 2014). It is important for the durum wheat breeders and the pasta industry to have an idea about protein quality, strength and cooking. The pasta industry requires some methods that can predict the protein quality and end-use quality of pasta products, especially the pasta cooking quality. Mixograph, alveograph, farinograph, glutograph, gluten index and SDS-sedimentation test are different

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methods to estimate semolina protein quality (AbuHammad *et al*., 2012). However, discriminative analysis with minimum sample is important. Mixograph, one of the rheological analysis, is used to distinguish gluten strength in wheat. Mixograph parameters can be used to predict durum wheat quality and pasta cooking quality. Durum wheat breeders pay attention to screening early generation lines for quality features to eliminate low quality lines. The aim of this study was to determine the dough traits of durum wheat varieties by mixograph which were grown in irrigated conditions in Central and Gözlü locations of Bahri Dagdas International Agricultural Research Institute.

MATERIALS AND METHODS

The study was conducted in 2015-2016 growing season with 4 standard varieties and 11 durum wheat lines (Variety of private sector, candidate line, Eminbey and C-1252) in randomized block design with three replications under irrigated conditions in Konya-center and Gözlü location. Some quality properties (thousand kernel weight, protein ratio, SDS sedimentation, semolina color (b value), mixograph development time, peak height, peak area, peak width, softening degree (slope), and energy (total area) were investigated. Whole meal and refined flour samples were obtained with a Perten 3100 mill (0.5 mm sieve) and with a Brabender Jr. mill (70 GG sieve). Thousand kernel weight were evaluated according to AACC method 55-10 (Anonymous, 2000). Durum wheat samples were tempered according to AACC method 26-95 (16% humidity) and milled by Brabender Jr. according to AACC method 26-50. Protein amount of the flours were measured by Leco FP 528 analyzer (Leco Inc, St Joseph, MI) according to AOAC 992.23 (Anonymous, 2009). SDS sedimentation were measured according to AACC method 56-70 (Anonymous, 2000). Color of semolina (b value, Yellowness) measured by Hunterlab mini scan XEplus (Anonymous, 1996). Mixograph parameters were defined according to AACC method 54-40A (Anonymous, 2000). Statistical analyses of the data obtained in the study were done by JMP11 (Anonymous, 2014b).

RESULTS AND DISCUSSION

***Thousand kernel weight*:** Thousand kernel weights are affected by changes in plant development cycles, giving information on semolina yield. The location mean of thousand kernel weight was determined as 33.01 g in Konya and 35.48 g in Gözlü. In this study thousand kernel weight varied between 30.26 -38.45 g in terms of location means. Line 3 (38.45 g) had the highest value in examined lines and Eminbey (33.84 g) had the highest value in examined varieties (Table 1). The mean of thousand kernel weight in the trial was 33.90 g, the mean of lines was 34.24 g, the mean of standard varieties was 32.97 g. It has been reported that the yield and quality characteristics of varieties are influenced by the climate and soil characteristics of the locality where they are grown and that these should be taken

Table 1. Thousand kernel weight and protein content values of durum wheat varieties.

Genotypes	Thousand Kernel Weight (g)			Protein Content (%)		
	Konya	Gözlü	Mean	Konya	Gözlü	Mean
2	34.76	38.18	36.47	13.67	14.35	14.01
3	39.50	37.40	38.45	13.30	14.76	14.03
4	36.92	36.80	36.86	13.29	13.67	13.48
6	31.62	32.52	32.07	13.16	13.02	13.09
7	32.34	28.18	30.26	14.34	14.03	14.18
9	32.20	31.06	31.63	13.71	14.16	13.94
10	31.30	37.86	34.58	14.85	13.27	14.06
11	29.70	34.62	32.16	14.01	14.62	14.31
12	31.08	36.90	33.99	14.66	14.13	14.39
13	33.68	39.40	36.54	13.45	14.77	14.11
14	30.02	37.32	33.67	14.31	14.79	14.55
Mean of lines	33.01	35.48	34.24	13.88	14.14	14.01
Variety of private sector	30.08	35.14	32.61	14.22	13.31	13.77
Candidate line	31.60	34.78	33.19	12.65	13.23	12.94
C-1252	30.68	33.78	32.23	13.26	13.83	13.55
Eminbey	31.20	36.48	33.84	14.50	15.04	14.77
Mean of standards	30.89	35.05	32.97	13.66	13.85	13.75
General mean	32.44	35.36	33.90	13.82	14.06	13.94
$LSD_{(0.05)}$	2.40	2.64	2.52	0.90	1.12	1.01
$CV_{(\%)}$	2.14	1.98	4.12	4.75	3.25	6.20

into account in variety selection (Aydoğan *et al*., 2007).

***Protein content*:** One of the goals of durum wheat breeding programs is to select genes with higher protein content. The amount of protein is desired to be more than 13% because protein content is the important factor that affects both rheological and cooking quality (Troccoli et al., 2000; D'Ovidio and Masci, 2004). The protein amount of wheat grain is a characteristic feature that is controlled by complex genetic arrangements under the high influence of environmental factors (Branković *et al*., 2018). In this study, the mean of protein content was determined as 13.82% in Konya and 14.06% in Gözlü. Protein content of genotypes ranged between 12.94 and 14.77% in terms of location means. The protein amount is highly affected by environmental conditions. Line 14 (14.55%) had the the highest value in examined lines and Eminbey (14.77%) had the highest value in examined varieties (Table 1). The mean protein content in the trial was 13.94%, the mean protein content of lines was 14.01%, and the mean of the standard varieties was 13.75%. The highest mean value was obtained from lines. Aydoğan *et al*. (2012) found that the mean protein content of 5 durum wheat varieties was 13.89% in irrigated conditions during 2009-2011. In a similar study, the average protein content of 9 different durum wheat was 12.57% (Demir *et al*., 2019).

***SDS sedimentation*:** SDS sedimentation (SDSS) is an important parameter that gives an idea about gluten strength in durum wheat quality breeding (Brites and Carrillo, 2001). Gluten strength and gluten extensibility influence pasta-making qualities of durum wheat (Pena, 2000). Gluten specifies the technological properties of durum wheat in pasta making, which is the final product. Sedimentation volume test is based upon the capability of the endosperm storage proteins to expand and flocculate in a lactic acid solution, showing positive correlations with bread- making quality and gluten strength and the cooking quality of pasta and with bread-loaf volume (Deng *et al*., 2013). Sedimentation value is expected to be high in durum wheat as well as in bread wheat. SDS sedimentation test is a good predictor of cooked firmness of pasta. Low volume of SDSS in wheat is associated with poor gluten traits. The mean SDS sedimentation value according to the locations was determined as 22.27 ml in Konya and 21.70 ml in Gözlü. Sedimentation value ranged between 13.75-29.75 ml in terms of location means in this research. Line 14 (29.75 ml) had the the highest value in examined lines and Eminbey (28.25 ml) had the highest value in examined varieties (Table 2). In the trial, the mean SDS sedimentation value was determined as 21.98 ml, the average of SDS sedimentation value of the lines was 22.07 ml, and the average SDS sedimentation value of the standard varieties was determined as 21.75 ml. The mean of lines was above the mean of varieties and trial. In studies conducted with durum wheat genotypes, SDS sedimentation values ranged between 19.5-31.3 ml (Sözen and Yağdı 2005) and 17.3-28.7 ml (Sakin *et al*., 2011).

***Semolina color (b)*:** The carotenoid concentration of durum wheat is an important criteria used in determining the quality of semolina and at the same time contributing to its nutritional value. In addition, the pasta preferences of the

Table 2. SDS sedimentation and color (b) values of durum wheat varieties.

Genotpyes	SDS Sedimentation (ml)			Color (b)		
	Konya	Gözlü	Mean	Konya	Gözlü	Mean
2	21.00	21.50	21.25	23.28	23.43	23.35
3	23.50	23.50	23.50	20.92	21.43	21.17
4	19.50	19.00	19.25	22.02	21.39	21.70
6	16.50	17.00	16.75	22.25	21.55	21.90
7	29.00	28.50	28.75	21.26	21.71	21.49
9	27.50	27.50	27.50	21.19	20.91	21.05
10	14.00	13.50	13.75	22.19	21.63	21.91
11	20.00	18.00	19.00	23.12	21.27	22.19
12	16.00	18.50	17.25	22.59	21.41	22.00
13	27.50	24.50	26.00	21.72	20.91	21.32
14	32.00	27.50	29.75	21.42	21.21	21.32
Mean of lines	22.41	21.73	22.07	21.99	21.53	21.76
Variety of private sector	20.00	20.00	20.00	20.59	20.31	20.45
Candidate line	21.00	20.50	20.75	20.41	20.72	20.56
C-1252	18.00	18.00	18.00	21.70	21.68	21.69
Eminbey	28.50	28.00	28.25	22.42	21.82	22.12
Mean of standards	21.88	21.63	21.75	21.28	21.13	21.20
General mean	22.27	21.70	21.98	21.80	21.42	21.61
$LSD_{(0.05)}$	1.90	2.60	2.25	1.80	2.40	2.10
$CV_{(\%)}$	4.75	3.45	7.19	2.53	3.21	3.09

consumers are determined to a great extent (Beleggia *et al*., 2011; Cabas-Lüchman and Manthey, 2020). The color of the final products varies according to the pigment content, processing conditions and various enzyme activities of the durum wheat varieties used in their production (Verlotta *et al*., 2010). Pasta color are under the control of variety and environmental factors. Among the color values, b value (yellowness value) is an important quality criterion for durum wheat. The carotenoid pigments found naturally in the seed are affected by many factors such as lipoxygenase and some other enzymes after grinding and storage, and the processing conditions of the pasta (Borrelli *et al*., 2000). Pasta color are under the control of variety and environmental factors. The colour of the wheat grain and the final products derives from phenotypic variations in the pigments present in the grain, which is based on genetic agents, growing conditions and technological processes (Ficco *et al*. 2014). In our study, mean color (b) value was determined as 21.28 in Konya and 21.13 in Gözlü according to location. Color (b) of genotypes ranged between 20.45 and 23.35 in terms of location means. Line 2 (23.35) had the the highest value in examined lines and Eminbey (22.12) had the highest value in examined varieties (Table 2). In the trial, the mean color value of lines was determined as 21.76, the mean color value of standard varieties as 21.20 and the mean of trial as 21.61. The mean value of standard varieties was above the mean of trial and the mean of the lines. Şahin *et al*. (2006) stated that b value of semolina ranged between 16.26 and 20.62 in their study.

***Mixograph parameter*:** Mixograph analysis is an effective and practical test to estimate the end use quality of durum wheat in a breeding program for breeders (Şahin *et al*., 2015). The mixograph measures the resistance of dough kneaded with flour and water by means of fixed and rotating pins and thus gives an idea of the quality of wheat and flour (Dong *et al*., 1992; Khatkar *et al*., 1996). Dough development time and resistance to kneading are determined from grahpic by mixograph. Mixograph development time ranged between 1.55 and 3.67 min in terms of location means. In parallel study, similar results were obtained and it was determined that the mixograph development time of some durum wheat ranged between 1.54 and 3.77 minutes (Demir *et al*., 2019). Line 7 (3.79 min) had the highest value in examined lines and Eminbey (3.67 min) had the highest value in examined varieties (Table 3). The mean development time of the lines in the trial was 2.51 minutes, the mean of the standard varieties was 2.91 minutes, the mean of trial was 2.61 minutes. The highest mean value was obtained from standard varieties.

In this research mixograph peak height ranged between 46.47 and 81.38%. Eminbey (78.80%) had the highest value in examined varieties (Table 3). The mean peak height of the lines in the trial was 65.96%, the mean of the standard varieties was 61.39% and the mean of trial was 64.74%. According the results, mean peak height of lines was higher than mean of standards. Abuhammad *et al*. (2012) stated that there were significant differences between cultivars for mixograph properties in their study. If the dough has high resistance to kneading, it is expected that the mixograph peak height will also be higher (AbuHammad *et al*., 2012).

Table 3. Mean values of mixograph parameters of Konya Central Location.

Genotypes	Development Time (min)	Peak Height (%)	Softening Degree (min/%)	Peak Width (%)	Peak Area (Nm)	Total Area (Nm)
2	1.98	60.71	15.58	2.97	57.00	303.00
3	3.05	61.92	9.66	11.02	113.00	340.00
4	2.88	46.47	6.46	3.73	81.00	260.00
6	2.04	58.32	13.49	2.94	62.00	291.00
7	3.79	77.60	11.69	13.47	142.00	370.00
9	3.14	81.38	21.21	5.39	113.00	396.00
10	1.68	57.29	19.23	2.19	55.00	257.00
11	1.55	70.16	22.79	3.44	59.00	341.00
12	2.42	54.89	12.33	2.79	68.00	285.00
13	1.84	80.41	28.85	3.50	78.00	363.00
14	3.20	76.42	10.06	15.13	165.00	407.00
Mean of lines	2.51	65.96	15.58	6.05	90.00	328.00
Variety of private sector	2.77	57.36	10.64	8.15	116.00	310.00
Candidate line	3.35	62.50	13.33	4.29	103.00	331.00
C-1252	1.85	46.88	10.66	2.20	54.00	236.00
Eminbey	3.67	78.80	10.00	14.86	163.00	401.00
Mean of standards	2.91	61.39	11.16	7.37	109.00	320.00
General mean	2.61	64.74	14.39	6.40	95.00	326.00
LSD $_{(0.05)}$	0.52	10.58	4.71	4.11	15.25	21.31
CV $_{(\%)}$	4.12	3.41	2.74	2.33	5.41	2.36

Aydoğan *et al*. (2012) found the peak height of two-year average of the 5 different durum wheat varieties between 57.27-67.84%. The results we found in this study are also consistent with other studies.

The softening degree is a parameter that gives an idea about the resistance of the dough. As the degree of softening increases, the strength of gluten and resistance to kneading decreases (Şahin et al., 2016). In this research mixograph softening degree (Slope) ranged between 6.46-28.85 min/%. Softening degree of examined lines were higher than examined varieties. Line 4 (6.46 min/%) had the lowest value in examined lines and Eminbey (10 min/%) had the lowest value in examined varieties (Table 3). The mean value of the softening degree of the lines in the trial was determined as 15.58 min/%, the mean of the standard varieties as 11.16 min/% and the mean of trial as 14.39 min/%. The lowest mean value was obtained from standard varieties.

Mixograph peak width ranged between 2.19 and 15.13% in this study. Line 14 (15.13%) had the highest value in examined lines and Eminbey (14.86%) has the highest value in examined varieties (Table 3). The mean of peak width of the lines in the trial was 6.05%, the mean of peak width of the standard varieties was 7.37% and the mean of trial was 6.40%. Peak width of examined lines were lower than examined varieties.

Mixograph peak area ranged between 54-165 Nm. Line 14 (165 Nm) had the highest value in examined lines and Eminbey (163 Nm) had the highest value in examined varieties (Table 3). The mean of peak area value of the lines in the trial was 90 Nm, the mean of peak area of the standard varieties was 109 Nm and the mean of trial was 95 Nm. When genotypes are compared, it was determined that peak area of examined lines were lower than examined varieties.

Mixograph total area ranged between 236-407 Nm. Line 14 (407 Nm) had the highest value in examined lines and Eminbey (401 Nm) had the highest value in examined varieties (Table 3). The mean of the mixograph total area value of the lines in the trial was 328 Nm, the mean of the mixograph total area value of the standard varieties was 320 Nm and the mean of trial was 326 Nm. The mean of the mixograph total area value of the lines was higher than the mean of trial and the mean of the standard varieties. Aydoğan *et al*. (2012) studied with 5 durum wheat in Konya central location in irrigated conditions. They found variation ranges in mixograph development time (1.83-2.70 min), peak height (57.27-67.84%), softening degree (22.88-39.17 min/%) and total area (291.96-402.46 Nm). In a similar research, Aydoan *et al*. (2014) studied with 8 durum wheat in Konya central location in irrigated conditions. They found variation ranges in mixograph development time (1.69-3.45 min), peak height (71.34-74.78%), softening degree (7.32-30.00 min/%), peak width (3.41-22.16%) and peak area (66.62-159.21 Nm) and total area (326.63-381.87 Nm). These mixograph parameters could be taken into account as practical selection criteria for the improving of high quality durum wheat varieties.

***Conclusion*:** During the year of the study, it was determined that there were differences between some quality characteristics and mixograph values that were examined in different environments under irrigated conditions. Quality characteristics of durum wheat is one of the most important objectives ofthe breeding program. The final product quality of durum wheat is sensitive to environmental conditions. Thousand kernel weight, protein content, SDS sedimentation, b color value, peak height, mixograf peak area and mixograph total area of examined lines were higher than examined standard varieties. Eminbey variety and Line 14 had the highest value in terms of analyzed quality parameters. Mixograph analysis is fast and work with less sample. It is suitable for assessing large number of durum wheat lines. The activity of wheat breeders has been focused on selecting lines with high yield and quality. In this study it was observed that the mixograph parameters could be efficient in identification of durum wheat quality. This information will aid durum wheat breeders to develop durum wheat varieties with targeted gluten strength.

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